

BIRLA INSTITUTE OF TECHNOLOGY & SCIENCE, PILANI, PILANI CAMPUS
CHEMICAL ENGINEERING DEPARTMENT

Course Title: Process Design Principles - I (CHE F314)

Mid Semester Test (Closed Book)

Marks: 75

Date: 11/10/17

Time: 90 minutes

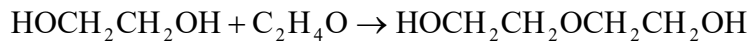
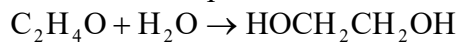
Note: Make the suitable assumption by clearly stating them, if necessary. Write all steps clearly.

1. (5 Marks)

A stream containing 500 mol/h of benzene and 50000 mol/h of air fed to absorption column. Benzene is recovered as per the heuristic by water as solvent. Water flow rate to the distillation column is 5000 mol/h. Based on the heuristic what should be the **total flow rate of distillate and bottom products**, if the desired product purity of benzene is 99%?

2. (5 Marks)

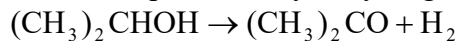
Ethylene glycol (HOCH₂CH₂OH), used as an antifreeze, is produced by reacting ethylene oxide with water. A side reaction produces an undesirable dimer, DEG:



Discuss the design guidelines with respect to decision making at level-3 corresponding to the use of excess amount of reactant.

3. (6 Marks)

Acetone is produced by dehydrogenation of isopropanol (IPA) as follows:



The heat of reaction at 570°F and 1 atm is 25,800 Btu/mol. Calculate the reactor heat load for producing 200 mol/h of acetone, if conversion is 0.75 and also suggest whether **the reactor is to operated adiabatically or isothermally based on reactor heat load. Also mention if a diluent or a heat carrier is required.**

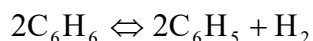
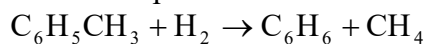
4. (4 Marks)

Consider the components and the destinations given below with their normal boiling points for a gas phase reaction. Identify the groups and the number of possible recycle streams? Provide Justification for your answer.

Component	Boiling Point (°C)	Destination Code
A	111	Valuable by product
B	-161	Reactant-recycle to R2
C	253	Reactant-recycle to R1
D	-253	Reactant-recycle to R1
E	80	Reactant-recycle to R2
F	-270	Reactant-recycle to R1
G	180	By-product as fuel

5. (5 Marks)

Benzene is produced from HDA process via following reactions:



If the fresh feed of toluene is 100 mol/h. The conversion of toluene in the reactor is 60% and selectivity (moles of benzene produced/mole of toluene reacted) is 0.75. The unconverted toluene is completely recovered in the separator recycled back to the reactor. **Calculate the total feed of toluene to the reactor.**

6. (15 Marks)

Consider a condensation process for recovering acetone from air stream (acetone = 10.3 mol/h and air = 687 mol/h). The feed stream is available at ambient conditions (77 °F and 1 atm).

- Draw a flow sheet for the acetone recovery process.
- If the condensation process operates at 15 psia, what temperature would be required to recover 99.5% of acetone?
- If the condensation process operates at 100 °F, what pressure would be required to condense 99.5% of acetone?
- Discuss the results obtained from (b) and (c).

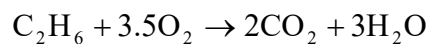
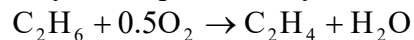
Vapor pressure data: Antoine equation, $\ln(p^*) = A - \frac{B}{C + T}$

where, p^* = vapor pressure in mm Hg, T = temperature in K

Acetone: $A = 16.6513$, $B = 2940.46$, $C = -35.93$

7. (15 Marks)

Ethylene is produced by the following reactions:

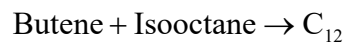
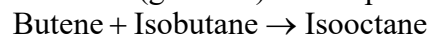


Develop a correlation for selectivity (S) and conversion (x) for the following data on product distribution **using method of linear least squares or method of averages**. Also calculate the optimum conversion corresponding to maximum yield.

Moles of C_2H_4 produced/mole of C_2H_6 converted	0.989	0.975	0.952	0.93	0.884	0.826	0.769
Moles of C_2H_4 produced/mole of C_2H_6 fed	0.099	0.146	0.190	0.233	0.265	0.289	0.308

8. (20 Marks)

Isooctane (gasoline) can be produced by the reactions:



The reactions take place in the liquid phase at 45 °F and 90 psia. Selectivity (S) is defined as Isooctane produced per mole of butene converted. The desired production rate is 918 mol/h. One feed stream contains 8% C_3 , 80% butene, and 12% n - C_4 , while the other contains 12% C_3 , 73% i - C_4 (isobutane) and 15% n - C_4 .

Draw the recycle structure of the flow sheet and calculate the stream flow rates (inputs, outputs, recycle flows, reactor inlet) in terms of design variables. Assume that the impurities present in feed streams are separated after reaction and utilized as fuel.

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